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JADS JT&E

JADS Special Report on Verification, Validation and Accreditation of Distributed Tests

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Joint Advanced Distributed Simulation
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EXECUTIVE SUMMARY

1.0 Introduction

The Joint Advanced Distributed Simulation (JADS) Joint Test and Evaluation program was chartered by the Deputy Director, Test, Systems Engineering and Evaluation (Test and Evaluation), Office of the Secretary of Defense (Acquisition and Technology) in October 1994 to investigate the utility of advanced distributed simulation (ADS) technologies for support of test and evaluation (T&E). The JADS Joint Test Force (JTF) is Air Force led, with Army and Navy participation, and is scheduled for completion in March 2000. JADS JTF conducted three tests of currently fielded systems using an ADS-enhanced test environment. The System Integration Test (SIT) explored ADS support of air-to-air missile testing; the End-to-End (ETE) Test investigated ADS support for command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) testing; and the Electronic Warfare (EW) Test examined ADS support for EW testing. The JADS JTF was also chartered to observe or to participate at a modest level in ADS activities sponsored and conducted by other agencies in an effort to broaden conclusions developed in the three dedicated test areas.

Verification, validation and accreditation (VV&A) are key methodologies required for the use of ADS in support of developmental test and evaluation (DT&E) and operational test and evaluation (OT&E). In keeping with the JADS charter to explore the critical constraints, concerns, and methodologies when using ADS for T&E, this report addresses the present state of the VV&A of ADS-enhanced test environments. It first assesses the status of the VV&A of ADS-enhanced test environments as represented by directives, regulations, and formal processes. Next it presents the VV&A processes used by each of the three JADS tests, lessons learned, and finally, the report draws conclusions and provides a recommended guide to the VV&A of an ADS-enhanced test environment.

2.0 Existing VV&A Guidelines

Currently there are three references available, or in the process of being published, which are of extreme importance to those interested in the VV&A of ADS-enhanced test environments. The first of these documents, the *Department of Defense (DoD) Verification, Validation, and Accreditation (VV&A) Recommended Practices Guide*, describes an overall methodology for the conduct of VV&A. The remaining two documents, the *Recommended Practice for Distributed Interactive Simulation--Verification, Validation, and Accreditation* and the *High Level Architecture (HLA) Federation Development and Execution Process (FEDEP): VV&A Overlay*, describe the VV&A methodologies used for the two most prominent forms of distributed simulation currently practiced. These directives, regulations, and the formal processes associated with them that apply to the VV&A of an ADS-enhanced test environment, while differing in their level of detail, all require the VV&A of an ADS-enhanced test environment when used to test a military system.

3.0 VV&A of the Three JADS Tests

The System Integration Test (SIT) and Electronic Warfare (EW) Test were primarily hardware-in-the-loop tests, or used hardware-in-the-loop simulations in place of actual hardware. Both used existing facilities with well-documented, verified and validated simulations. The End-to-End (ETE) Test, however, modified a large-scale battlefield simulation and designed and developed a simulation of the major component of its ADS test environment. All three tests were different in both the way they developed the ADS-enhanced test environment and the way they applied the VV&A process. The SIT and EW Test were primarily concerned with the verification and validation (V&V) of the environment. The nodes were already verified and validated. The ETE Test, on the other hand, had to first V&V the nodes and then V&V the environment. Several lessons were learned during the VV&A of the three JADS tests. The two most important lessons learned were that V&V are affordable if performed in conjunction with test design, integration, and functionality testing, and that VV&A reduce risk for the tester. The VV&A of an ADS-enhanced test environment should proceed hand-in-hand with the design and development of the environment. The primary role of VV&A is to reduce risk. If it doesn't, it probably isn't needed.

4.0 Guide to the VV&A of an ADS-Enhanced Test Environment

Each ADS-enhanced test must tailor the specifics of the VV&A process to the needs and requirements of the test. VV&A must start at the beginning of the test process and the majority of the effort should be concentrated in high-risk areas. This report proposes a guide to the VV&A of an ADS-enhanced test environment that associates VV&A activities with a JADS-developed ADS test planning methodology. This test planning methodology is proposed in the *JADS Special Report—A Test Planning Methodology-From Concept Development Through Test Execution.* The referenced report tailors the steps as outlined in the High Level Architecture (HLA) Federation Development and Execution Process (FEDEP). The result is an ADS-enhanced test planning and implementation methodology.

5.0 Conclusions

VV&A of ADS-enhanced test environment when used to test a military system are required by the various DoD and service directives and regulations but doesn't necessarily have to be an onerous burden. A tailored, requirements-driven process, which is integrated into the test from the beginning, can be an affordable activity that reduces risk. In fact, testers already do V&V. They just don't document them as such. These activities if properly documented can become the V&V that lead to accreditation.

1.0 Introduction

The Joint Advanced Distributed Simulation (JADS) Joint Test and Evaluation (JT&E) was chartered by the Deputy Director, Test, Systems Engineering and Evaluation (Test and Evaluation), Office of the Secretary of Defense (OSD) (Acquisition and Technology) in October 1994 to investigate the utility of advanced distributed simulation (ADS) technologies for support of developmental test and evaluation (DT&E) and operational test and evaluation (OT&E).

The JADS JT&E charter focused on three issues: what is the present utility of ADS, including distributed interactive simulation (DIS), for test and evaluation (T&E); what are the critical constraints, concerns, and methodologies when using ADS for T&E; and what are the requirements that must be introduced into ADS systems if they are to support a more complete T&E capability in the future.

The JADS Joint Test Force (JTF) investigated ADS applications by considering three slices of the T&E spectrum: the System Integration Test (SIT) explored ADS support of air-to-air missile testing; the End-to-End (ETE) Test investigated ADS support for command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) testing; and the Electronic Warfare (EW) Test examined ADS support for EW testing. Each test focused on the three issues listed above. The JTF was also chartered to observe or participate at a modest level in ADS activities sponsored and conducted by other agencies in an effort to broaden conclusions developed in the three dedicated test areas.

One of the major issues associated with the use of ADS is the credibility of the models and simulations (M&S) used and the credibility of their interactions over a distributed network. Credibility is commonly measured by verification and validation (V&V) and then formally approved as adequate for use for a specific application by accreditation. The V&V of distributed simulations are formally required by Department of Defense (DoD) Instruction 5000.61, *DoD Modeling and Simulation Verification, Validation and Accreditation*, prior to their use in testing.

Verification, validation and accreditation (VV&A) are key methodologies required for the use of ADS in support of DT&E and OT&E. In keeping with JADS charter to explore the critical constraints, concerns, and methodologies when using ADS for T&E, this report will assess the present state of the VV&A of ADS-enhanced test environments by first assessing the formal status of the VV&A of ADS-enhanced test environments as represented by directives, regulations, and formal processes. It will then present the VV&A processes used by the three aforementioned tests conducted by the JADS JTF. Following this will be lessons learned as a result of conducting the VV&A processes and a guide to the VV&A of an ADS-enhanced test environment. Finally, the report will provide some conclusions and recommendations.

2.0 Verification, Validation and Accreditation

Prior to any discussion of VV&A, it is necessary to first establish a common frame of reference. The definitions that follow are taken from the DoD Manual 5000.59, *DoD Modeling and Simulation (M&S) Glossary.*

Accreditation. The official certification that a model or simulation is acceptable for use for a specific purpose.

It is important to note that the definition states that the accreditation is for a specific purpose. No mention is made of a class accreditation or general-purpose accreditation. Missing from the definition is the reference to federations of models and simulations present in the definition used in DoD Instruction 5000.61.

Federation Element. Term applied to an individual model and/or simulation that is part of a federation of models and simulations.

This and the following definition, taken from DoD Instruction 5000.61, form the basis of what is commonly referred to within JADS as the synthetic environment.

Federation of Models and Simulations. A system of interacting models and/or simulations, with supporting infrastructure, based on a common understanding of the objects portrayed in the system.

Model. A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process.

Modeling and Simulation. The use of models, including emulators, prototypes, simulators, and stimulators, either statically or over time, to develop data as a basis for making managerial or technical decisions. The terms "modeling" and "simulation" are often used interchangeably.

Or, as stated in DoD Instruction 5000.61:

Modeling and Simulation. The development and use of live, virtual, and constructive models including simulators, stimulators, emulators, and prototypes to investigate, understand, or provide experimental stimulus to either (1) conceptual systems that do not exist or (2) real life systems which cannot accept experimentation or observation because of resource, range, security, or safety limitations. This investigation and understanding in a synthetic environment will support decisions in the domains of research, development, and acquisition and analysis, or transfer necessary experimental effects in the education, training, and military operations domain.

Within JADS, M&S, when distributed, are commonly referred to as ADS.

Simulation. A method for implementing a model over time.

Validation. The process of determining the degree to which a model or simulation is an accurate representation of the real world from the perspective of the intended uses of the model or simulation.

The perspective of the intended uses of a model is normally expressed in terms of requirements for the model. This provides a basis for determining the degree to which a model is an accurate representation.

Verification. The process of determining that a model or simulation implementation accurately represents the developer's conceptual description and specification. Verification also evaluates the extent to which the model or simulation has been developed using sound and established software engineering techniques.

Again, the developer's conceptual description and specifications are expressed as requirements for the model. The latter sentence in this definition is felt to apply more to software verification, validation and certification (VV&C).

The definitions given are deemed important for the purposes of this report. It is recommended that the reader review all the definitions given in DoD Manual 5000.59 for a more complete understanding of VV&A.

2.1 DoD Regulation 5000.2

DoD Regulation 5000.2, *Mandatory Procedures for Major Defense Acquisition Programs (MDAPS) and Major Automated Information System (MAIS) Acquisition Programs*, is important in the consideration of the VV&A of ADS-enhanced test environments. This regulation authorizes the use of accredited modeling and simulation, as appropriate, throughout a system's life cycle in support of the various acquisition activities including test and evaluation. The requirement that accredited models and simulations be used implies that the appropriate verification and validation has been performed.

2.2 DoD Directive 5000.59

DoD Directive 5000.59, *DoD Modeling and Simulation (M&S) Management,* establishes DoD policy, assigns responsibilities, and prescribes procedures for the management of models and simulations. Key established VV&A policies are the requirements for the DoD components to establish verification, validation, and accreditation policies and procedures for M&S applications managed by the DoD component, and M&S applications used to support the major DoD decision making organizations will be accredited.

2.3 DoD Instruction 5000.61

DoD Instruction 5000.61, *DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation*, implements policy, assigns responsibilities, and prescribes procedures for the VV&A of DoD M&S.

Of particular importance is the policy implemented within DoD 5000.61. Specifically, the instruction states

1. DoD components shall establish VV&A policies and procedures for M&S they develop and manage. The "DoD M&S executive agent" (MSEA) responsible for a common or general-use M&S shall follow DoD component VV&A policies and procedures for that application, unless otherwise specified by the Under Secretary of Defense for Acquisition and Technology (USD(A&T)).
2. M&S used to support the major DoD decision making organizations and processes (such as the Defense Planning and Resources Board; the Defense Acquisition Board (DAB); the Joint Requirements Oversight Council; and the DoD Planning, Programming, and Budgeting System (described in references (b) through (f))) shall be accredited for that use by the DoD component sponsoring the application. Likewise, M&S used for joint training and joint exercises shall be accredited for that purpose by the application sponsor.
3. Each DoD component shall be the final authority for validating representations of its own forces and capabilities in joint-, general-, and common-use M&S applications and shall be responsive to the other DoD components to ensure they are appropriately represented.

In addition, the USD (A&T) will, through the DoD Executive Council on Modeling and Simulation, designate the Defense Modeling and Simulation Organization (DMSO) as the DoD focal point to be the central source of DoD VV&A data and information and to assist DoD and non-DoD organizations, as requested, in resolving VV&A issues or obtaining information on DoD VV&A activities.

Key among the procedures stated in the instruction is that V&V will be required after the effective date of the instruction for all major M&S developments. Major M&S include, but are not limited to, M&S whose intended application will require accreditation by DoD or component policy; that will be elements of a federation of models and simulations; that are intended for reuse; whose application involves safety of life; and whose development will involve the commitment of significant DoD resources. V&V are also required when existing models and simulations undergo major upgrade or modification and will be incorporated into the development and life-cycle management processes for all major M&S. V&V are encouraged for all major M&S currently in use in the DoD.

The requirement to V&V M&S developments that require accreditation establishes the need to V&V federations or synthetic environments that will be used in the acquisition process including test and evaluation.

2.4 Service Regulations

2.4.1 Army Policies, Procedures, and Guidelines

Army Regulation (AR) 5-11, *Management of Army Models and Simulations*, prescribes policy and guidance and assigns responsibilities for the management of Army models and simulations. Included in this regulation is the Army policy on VV&A.

Of interest to Army testers is the requirement that "VV&A activities will be included in the simulation support plan required for all Army acquisition strategies for Acquisition Category I and II and non-major programs. A summary of the VV&A status of M&S used or proposed for use to support test and evaluation for an acquisition program, to include resources required, will be included in the program's Test and Evaluation Master Plan (see DoD 5000.2-R)."

In addition, "VV&A for a federation of M&S will adhere to not only the general VV&A policies and procedures for each individual M&S, but will also consider system compliance, compatibility, and interoperability requirements. VV&A of a federation will ensure credible results of the integrated system as a whole. Each unique application configuration of a federation requires VV&A."

With regard to accreditation, the regulation states that "M&S used to support major DoD decision making organizations and processes (such as the Defense Planning and Resources Board (DPRB); the Defense Acquisition Board (DAB); the Joint Requirements Oversight Council (JROC); and the DoD Planning, Programming, and Budgeting System (PPBS)) will be accredited specifically for that usage by the applicable Army application sponsor."

It goes on to say "Accreditation is a management responsibility of the application sponsor, assisted by the V&V agent. The specific use of the M&S must be considered in context with its capabilities and limitations. Accreditation includes data inputs, scenarios, and the operators-analysts-trainers who will use the M&S."

The Army regulation does provide for the accreditation of M&S for a generic set of applications. However, each specific usage of that M&S still requires accreditation by the specific application sponsor.

Department of the Army Pamphlet (DA PAM) 5-11, *Verification, Validation, and Accreditation of Army Models and Simulations,* gives procedures for the "Army Model and Simulation Management Program" (AR 5-11). The objective of this pamphlet is to assist the models and simulations developer, proponent, and application sponsor in conforming to the VV&A policies prescribed in AR 5-11. This pamphlet also provides guidance for the development, execution, and

reporting of all VV&A activities. This pamphlet does not cover data certification procedures, but it does address data certification in reference to proper M&S use.

DA PAM 5-11 is currently under revision to update procedures for the Army Model and Simulation Management Program. It will provide new guidance for compliance with the high level architecture (HLA) and revised instructions for the development, execution, and reporting of all VV&A activities.

2.4.2 Navy Policies, Procedures, and Guidelines

The Secretary of the Navy Instruction (SECNAVINST) 5200.40, *Verification, Validation, and Accreditation (VV&A) of Models and Simulations*, is the Navy's implementation of DoD Directive 5000.59 and DoD Instruction 5000.61 that requires the DoD components to establish VV&A policies, procedures, and guidelines for M&S applications. It applies to both Navy and Marine Corps activities.

The instruction states that M&S activities that are "...used significantly in supporting the development of either the Department of the Navy (DON) program objectives memorandum (POM) or analysis of alternatives" will be verified and validated, as set forth in the instruction, prior to their use. The instruction also requires that these M&S activities must be accredited by the appropriate accreditation authority prior to using them in support of the above applications. It does allow, however, the accreditation authority to tailor the VV&A process to meet specific requirements and objectives while working within existing resource constraints. The accreditation authority is specified in SECNAVINST 5000.2B, *Implementation of Mandatory Procedures for Major and Non-Major Defense Acquisition Programs and Major and Non-Major Information Technology Acquisition Programs.*

The instruction also contains a description of the Navy's M&S development process with key elements of the VV&A process emphasized throughout.

2.4.3 Air Force Policies, Procedures, and Guidelines

Air Force Instruction 16-1001, *Verification, Validation and Accreditation (VV&A)*, requires that all Air Force M&S applications supporting the major DoD decision making organizations or processes specified in DoD 5000.59 (paragraph D.8) and Air Force input to these DoD organizations will be accredited for their intended purpose. The instruction further states that all executed V&V activities will support the model acceptance/accreditation requirements defined by the accreditation authority.

Like the previous service policies, procedures, and guidelines, this instruction also contains a VV&A process. Unlike the other services, however, this process does not appear to be tied to the M&S requirements but rather to accreditation requirements established by the accreditation authority. The minimum accreditation requirements cited appear to focus more heavily on M&S development history, past applications, configuration control and similar requirements. To be fair,

however, the instruction does require the M&S capabilities and credibility, based on V&V status to be compared to the application criteria.

2.5 Assessment of Current ADS VV&A Methodologies

There are currently three references available, or in the process of being published, that are of extreme importance to those interested in the use of ADS-enhanced test environments. The first of these documents, the *Department of Defense (DoD) Verification, Validation, and Accreditation (VV&A) Recommended Practices Guide,* describes an overall methodology for the conduct of VV&A. The remaining two documents, the *Recommended Practice for Distributed Interactive Simulation --Verification, Validation, and Accreditation* and the *High Level Architecture (HLA) Federation Development and Execution Process (FEDEP): VV&A Overlay*, describe the VV&A methodologies used for the two most prominent forms of distributed simulation currently practiced.

2.5.1 Department of Defense Verification, Validation, and Accreditation Recommended Practices Guide

The *DoD VV&A RPG* is an outstanding guide that contains something for every developer and user in DoD involved in the VV&A of an ADS-enhanced test environment.

It contains sections that provide to the decision makers a quick overview of VV&A and information on the accreditation process. It also provides program managers a quick overview of what VV&A are all about as a necessary introduction. Program managers will also be interested in the principles and processes of VV&A as they incorporate these into their programs. Finally, it assists program managers in preparing senior decision makers for the accreditation decision.

The technical staff, whose job is to do the actual V&V, should read the entire document. In addition to the sections noted above, it will give users valuable guidance on specific techniques that are used in V&V and will provide common reporting formats to help them document the VV&A effort. The current *DoD VV&A RPG* is available at the DMSO website **(www.DMSO.mil).**

The *DoD VV&A RPG* is currently under revision and will soon be released for general use. The revision will incorporate the use of web technology to allow the user to navigate a focused path based upon the user's function with respect to VV&A. The program manager may follow a thread that addresses VV&A at the program level or may follow specific links for more detailed information. The practitioner can immediately access detailed information on how to conduct VV&A. The revised RPG is scheduled to be available on the DMSO web site in March 2000.

2.5.2 Recommended Practice for Distributed Interactive Simulation --Verification, Validation, and Accreditation

The *Recommended Practice for Distributed Interactive Simulation--Verification, Validation, and Accreditation* (DIS RPG) establishes guidelines for the VV&A of DIS exercises and includes the use of DIS-enhanced test environments. It provides "how to" procedures for planning and conducting DIS exercise VV&A.

The DIS RPG is intended for use by persons responsible for or participating in DIS-enhanced test environment VV&A activities (e.g., VV&A agents, VV&A teams, test managers, test architects). It also provides VV&A guidance to enhanced test environment users/sponsors and developers.

The DIS RPG (Institute of Electrical and Electronics Engineers [IEEE] 1278-4) is part of a set of IEEE standards (IEEE 1278) and supporting documentation that includes standards for application protocol and communication services; profiles standards to support DIS interoperability; a recommended practice for exercise management and feedback that provides guidelines for setting up and conducting a DIS exercise.

2.5.3 HLA VV&A FEDEP Overlay Process

An RPG for high level architecture (HLA) VV&A has not yet been published but is presently being worked. The HLA VV&A process has been developed and mapped to the HLA development process, known as the federation development and execution process (FEDEP) model. The mapping of the VV&A process to the FEDEP allows the user of an enhanced ADS test environment to tailor the VV&A effort to the test. Information about the HLA VV&V FEDEP overlay process is available from DMSO.

Once the VV&A effort is tailored, the *DoD VV&A RPG* can be used to provide decision makers, program managers, and technical staff valuable guidance on the VV&A process until such time as the HLA VV&A RPG is published.

3.0 VV&A's Role in JADS JTF Distributed T&E

As mentioned previously, the JADS JTF conducted three tests of currently fielded systems using an ADS-enhanced test environment. The SIT and EW Test were primarily hardware-in-the-loop (HWIL) tests, or used hardware-in-the-loop simulations in place of the actual hardware. Both utilized existing facilities with well-documented, verified and validated simulations. The ETE Test, however, was required to develop, or modify, large-scale battlefield simulations and had to design and develop a simulation of the major component of its ADS-enhanced test environment. All three tests were different in both the way they developed the ADS-enhanced test environment and the way they applied the VV&A process. The SIT and EW Test were primarily concerned with the verification and validation of the environment. The nodes were already verified and validated. The ETE Test, on the other hand, had to first V&V the nodes and then V&V the environment.

3.1 System Integration Test VV&A

A major objective of the SIT was to evaluate the validity of the missile performance data obtained using the ADS configurations. V&V methods developed for this purpose were consistent with those in the *DoD Verification, Validation and Accreditation (VV&A) Recommended Practices Guide*, specifically bottom-up testing, functional testing, data integration testing, predictive validation, and comparison testing.

The missile HWIL simulations had been previously verified for their intended uses. Therefore, the distributed test verification was to confirm that the ADS configuration operated as designed when the nodes were real time linked through an ADS network and could be used to replicate an actual live fire test including the necessary data collection. Verification was an incremental and iterative process beginning pretest and continuing throughout the missions. The structured approach began with systematic check-out of each stand-alone simulator/facility, followed by testing of each pair of linked nodes, and culminated with the check-out of the complete linked architecture consistent with the bottom-up testing method in the DoD RPG.

The objective of the validation process was to demonstrate that the performance of the missile in the HWIL lab, driven by data from the aircraft, was consistent with that of an actual missile live fire profile under the same conditions.

The preferred method for validation would be to replicate previous live fire test profiles using the ADS configuration and to directly compare results using quantitative techniques. However, several complications prevented this direct comparison.

Because of these complications, the validation method employed used a multistep process.

- The validity of the missile HWIL simulation itself was established by comparison to live fire data consistent with the predictive validation method in the DoD RPG.

- The validity of each SIT linked run was judged by missile experts based on a qualitative assessment of whether the missile HWIL simulation responded properly to the inputs received during the run.
  - The validity of selected SIT linked runs was established by comparison to HWIL lab stand-alone runs, consistent with the comparison testing method in the DoD RPG. **NOTE:** In this case, the missile HWIL simulation was employed as a truth source for data comparison purposes, since it was a validated representation of the actual missile (as established in the first step above).

This approach compared statistical distributions of significant performance parameters, affording a higher level of confidence in the comparisons. In addition, this technique allowed for the validation of profiles for which no live data existed.

3.2 End-To-End Test VV&A

The ETE Test was designed to evaluate the utility of ADS to support testing of C4ISR systems. The test focused on the Joint Surveillance Target Attack Radar System (Joint STARS) as one component of a representative C4ISR system. The ETE Test also evaluated the capability of the JADS Test Control and Analysis Center (TCAC) to control a distributed test of this type and remotely monitor and analyze test results.

Since JADS is a DoD-sponsored joint test, the overall guide for the V&V of the JADS End-to-End (ETE) Test was the *DoD VV&A RPG*. The JADS ETE Test utilized the IEEE Standard 1278 for DIS to develop its ADS-enhanced test environment. The *DoD VV&A RPG* advocated the use of the DIS nine step VV&A process for the VV&A of the DIS-enhanced test environment.

The DIS nine step VV&A process was developed with the knowledge that it must be tailored to each individual use. The tailoring of the VV&A process resulted in the JADS ETE Test VV&A process model shown in Figure 1.

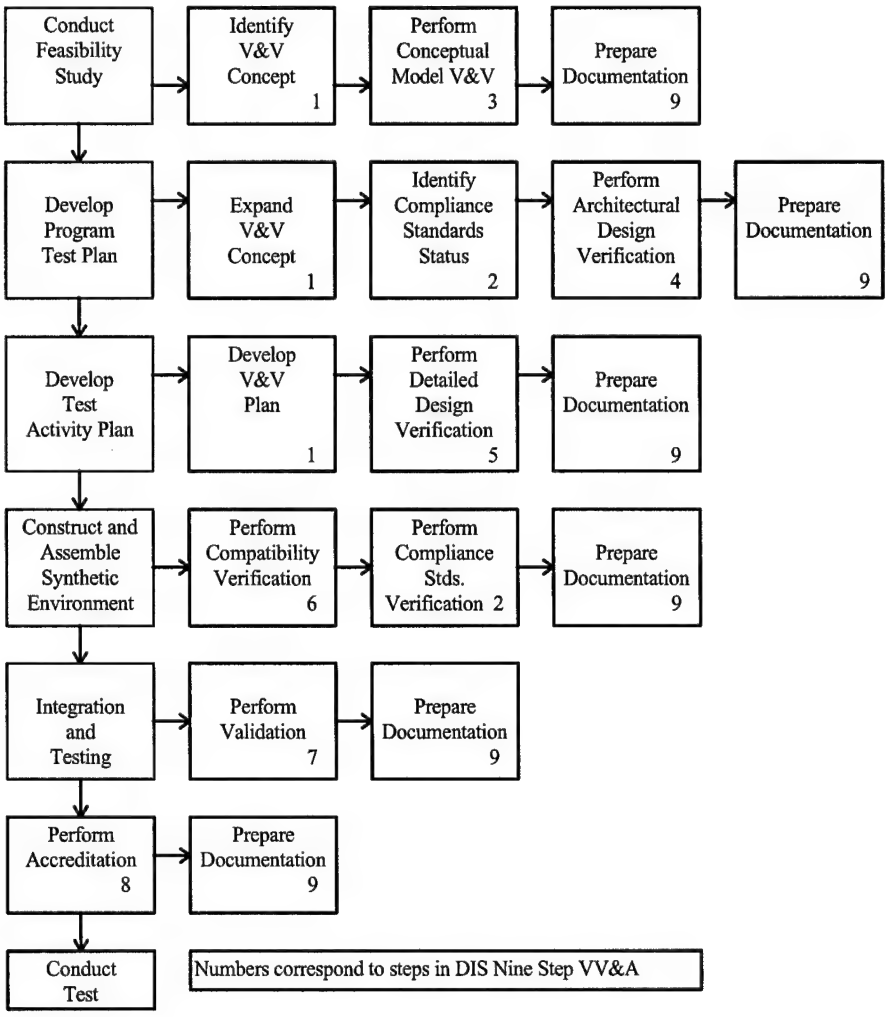

Figure 1. JADS ETE Test VV&A Process Model

In the JADS ETE Test VV&A process model, test events consisting of planning, constructing and assembling the synthetic environment (SE); integrating and testing the SE; accrediting the SE; and conducting the test all proceed on the left side from top to bottom. The V&V events including documentation proceed to the right for each major test event.

The major change from the DIS nine step VV&A process was the inclusion of the ADS-enhanced test environment accreditation as a part of the test process, resulting in an eight step V&V process. Accreditation is not a part of the DIS exercise process in the DIS VV&A process model. Instead, it is shown as a part of the VV&A process and by implication is not something that is required prior to conducting the DIS exercise. When ADS is used in support of operational and developmental testing, accreditation of M&S is a management function and is a mandatory part of the test process.

The V&V of the ETE Test ADS-enhanced environment were based upon the functional requirements and acceptability criteria that were taken from the test plans and other documents

that describe the test environment. The V&V agent developed the V&V plan by identifying the tasks required to satisfy these requirements and the acceptability criteria in a manner that matched and complemented the test activity plan, test requirements, component requirements, available resources, and timelines.

3.3 Electronic Warfare Test VV&A

A major objective of the EW Test was to evaluate the validity of the ADS-produced engagements when compared to the open air range (OAR) and hardware-in-the-loop (HITL) representations of the same engagements. The EW Test team had two opportunities to accredit the Phase 2 test environment. The first opportunity occurred pretest and used the results of the formal acceptance and integration testing JADS accomplished as part of the test preparation and rehearsal. The second opportunity used the correlation of the ADS-based testing with the results from the OAR test and from the HITL test to determine if the results from the federation were valid. The efforts undertaken to accredit the federation are described below.

3.3.1 Phase 2 V&V

The results of the Phase 2 federate acceptance test (FAT) and federation integration tests (FIT) were presented to the accreditation board prior to the JADS test readiness review. The team reported that in three instances the aircraft appeared to hover. The cause could not be established and the board was concerned that other issues might be present that would make the data invalid. The accreditation authority gave the EW Test team a chance to remedy or address the hovering aircraft issue and look for other issues before executing Phase 2 as scheduled. The hovering aircraft was addressed and no other issues were found. The federation was accredited. However, the V&V plan had to be republished after Phase 2 execution to satisfy the accreditation board.

The EW Test architecture used several software components that were not models in the traditional sense. These components fit into two categories. The first category was HLA-compliant software that acted as a gateway to the federation allowing either a non-HLA-compliant model or data collection software to interface with the rest of the federates. The critical issues for this software were that data were not corrupted and that data were not delayed excessively as they were passed through the gateway. The second category was HLA-compliant software that published data from a script. In this software, the critical issues were the validity of the script and ensuring the software did not corrupt or delay the data. Neither category of software was independently accredited. The EW Test team used an acceptance test to verify that the critical issues were met. The acceptance testing supported the V&V of the software and each component was accredited as part of the federation.

3.3.2 Phase 3 V&V

The Phase 3 test environment was the same as in Phase 2 except for the jammer federate. Consequently, for Phase 3, the V&V addressed critical functionality and fidelity aspects of the jammer in the installed systems test facility (ISTF). V&V addressed three key data sources: threat parameters, jammer parameters, and aircraft radar cross section. Accreditation of the threats

consisted of a documentation search and key personnel interviews to determine limitations that could impact the JADS effort. During V&V for Phase 2, JADS was able to find limited accreditation information on the Air Force Electronic Warfare Evaluation Simulator (AFEWES) threats. Accreditation information was directed at a threat baseline established through the intelligence community and documented in the electronic warfare integrated reprogramming (EWIR) database. VV&C were provided by AFEWES following established OAR quality control procedures. On the receiver side of the jammer, threat parameters from AFEWES were transformed by Advanced Tactical Electronic Warfare Environment Simulator (ATEWES) radio frequency (RF) signal generation capabilities (e.g., correct power, correct RF waveform). VV&C of threat parameters were performed prior to the FAT by Georgia Tech Research Institute (GTRI) and approved. Due to the critical functions ATEWES performed, continuous monitoring of threat parameters was done during Phase 3 execution. Aircraft radar cross section was approved by the EW Test integrated product team (IPT) and the VV&C were provided by the results of AFEWES quality control procedures. No issues were identified with key data sources during Phase 3 V&V. The results of these V&V activities were reported to and approved by the JADS accreditation board prior to test execution.

4.0 VV&A Lessons Learned

Several lessons were learned, or relearned, during the VV&A of the three JADS tests. They are presented here in roughly the same order as they would apply during the VV&A of a test environment.

The primary role of V&V during the conduct of an ADS-enhanced test is to reduce risk and meet policy requirements. The tester must have a high degree of confidence that the ADS-enhanced test environment will work prior to conducting costly and resource intensive test events. V&V can provide that high degree of confidence. The greater the risk, the more V&V are required. Low risk test environments require only enough V&V to meet policy requirements.

Requirements must exist before any V&V can be conducted. This is all right because a federation needs requirements before it can be developed. If the developer of the federation cannot state what it is supposed to do, it is extremely difficult to build and V&V the federation. This holds true for both the overall federation and the individual federates that comprise the federation. The level of V&V should match the level of sophistication of the requirements and their associated acceptability criteria. When the requirements and acceptability criteria are conceptual in nature, only conceptual V&V can be conducted. As the requirements become more detailed and refined, the V&V should become more detailed and refined.

Involve the accreditation folks early in the process. They are responsible for developing the acceptability criteria based upon the test requirements. The V&V plan, with its associated cost estimate, cannot be developed until the acceptability criteria are agreed upon between the test manager and the accreditation authority.

Acceptability criteria are specifications the federates and federation must meet. V&V are the testing required to determine how well they meet specifications. Requirements must exist before acceptability criteria can be developed. Acceptability criteria are a measure of the risk the accreditation authority is willing to accept prior to conducting the test.

If a V&V activity does not reduce risk it is probably not needed. The developer wants to know how well the federates and federation meet the requirements in order to proceed with minimal risk. Risk reduction is important because there are always a limited number of test events, either because of money, time, or limited availability of test assets. Therefore, the tester wants to maximize the value received from a test event and minimize the chance of something going wrong that would prevent collecting valid system under test (SUT) data. This is done by conducting V&V.

V&V are affordable, provided they are integrated into federates and federation testing. The developer's first thought should be what do I want my federation to do. The second thought should be how am I going to test or V&V it. The V&V process must be integrated into the test process from the beginning.

Most testers already do V&V; they just don't realize and document them as such. A test developer needs to know if the ADS-enhanced test environment provides valid SUT data prior to using it. To accomplish this a series of tests that will reduce the risk of proceeding is developed. This series of tests, if documented, can become the V&V required prior to accreditation.

Tailor the V&V process. Unneeded V&V kill trees, cost time and money, and do nothing to reduce risk.

It is often impossible to fully validate an ADS-enhanced test environment. This is because the real world depicted by the environment is nonexistent or is not well documented. An example would be an enemy corps rear area. We can depict them doctrinally, but until they take to the field, we can not validate our depiction. Validation of an ADS-enhanced test environment is often a matter of getting a group of subject matter experts (SME) to agree that your test environment is a valid representation of reality without actually knowing what reality is. Involve the accreditation authorities in selecting the SMEs and they will be more willing to accept their findings.

No complex system is ever used the way the designer thought it would be used. This will have an impact on V&V. V&V should be able to detect this deviate usage and determine what effect it will have on the system and the synthetic environment.

V&V should consider breakdowns or faults in the SUT. In our zeal to build perfect simulations, we often forget that everything breaks or malfunctions at some point in its usage. Often, reliability data or predictions are available to use in the simulations. V&V must determine that the simulations behave according to the reliability data or predictions.

V&V are never-ending processes. The tester always needs to know if the ADS-enhanced test environment is working correctly. For complex systems of systems environments, the tester must conduct V&V while collecting SUT data in order to prove post-test that valid SUT data have been collected. Additionally, the ADS-enhanced test environment may not exist in its test configuration until the first test event is conducted. Also, complex test environments may vary slightly from one test event to another and still be valid. Conducting some form of V&V during each test event will tell the tester that the test environment is valid.

5.0 Guide to the VV&A of an ADS-Enhanced Test Environment

As stated in the lessons learned, the VV&A of an ADS-enhanced test environment should proceed hand-in-hand with the design and development of the environment. The *JADS Special Report—A Test Planning Methodology-From Concept Development Through Test Execution* at www.JADS.abq.com[1] outlines the steps in planning and implementing an ADS-based test. The methodology tailors the steps given in the HLA FEDEP model to test and evaluation applications, resulting in an ADS-enhanced test environment. This is an outstanding guide on how to plan an ADS-based test and is highly recommended.

This guide to the VV&A of an ADS-enhanced test environment will associate the appropriate VV&A activities with the activities contained in the ADS-based test planning and implementation process.

Included in the test planning methodology is a top-level test concept development process that incorporates decision elements associated with the use of ADS for test and evaluation. This test concept development process includes Step 8, Evaluate Adequacy of the Environment. The purpose of this step is to satisfy the test planners that the conceptual ADS-enhanced test environment is rich enough in terms of meaningful interactions to support a sound test. This can also be considered as early conceptual model validation and further supports the lesson learned that we often perform V&V and don't realize it. In fact, by documenting the process the tester could partially satisfy the requirement to perform conceptual model validation.

The HLA FEDEP model lists six steps needed to develop and execute an ADS-based test. It should be noted here that these six steps might involve loop-backs as the development and execution of the test proceeds. When a loop-back occurs, the corresponding V&V will be repeated if changes are made to the design or execution of the test. The six steps, as listed in the test planning methodology, are

Step 1: Define Distributed Test Objectives
Step 2: Develop Conceptual Model
Step 3: Design Distributed Test
Step 4: Develop Distributed Test
Step 5: Integrate and Test Architecture
Step 6: Execute Distributed Test and Analyze Results

An ADS-based test has the requirement that the ADS-enhanced test environment and its components must be accredited before the test can be executed. Since the accreditation authority is in the test development and execution chain, a step needs to be added to the model between step 5 and step 6. Step 5a becomes "Accredit ADS-Enhanced Test Environment."

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[1] After 1 March 2001 refer requests to Headquarters Air Force Operational Test and Evaluation Center History Office (HQ AFOTEC/HO), 8500 Gibson Blvd. SE, Kirtland Air Force Base, New Mexico 87117-5558, or SAIC Technical Library, 2001 North Beauregard St., Suite 80, Alexandria, Virginia 22311.

5.1 Step 1. Define Distributed Test Objectives

From the test planning methodology, the test sponsor or evaluator and the distributed test development team define and agree on a set of objectives and document what must be accomplished to achieve those objectives. This is a test planning step and is addressed by the test planning methodology. (JADS Special Report—A Test Planning Methodology-From Concept Development Through Test Execution)

Early in this step the test manager should appoint a V&V lead. If the test manager is the accreditation authority, also appoint an accreditation team lead; if not ask the accreditation authority to appoint an accreditation team lead to be a member of the IPT for the test.

As the set of objectives for the test matures, the accreditation team lead and the V&V lead should discuss accreditation requirements and how the V&V will be conducted. Broad requirements and acceptability criteria should be arrived at so that the V&V plan can be developed. Issues such as V&V products required by the accreditation team, independent V&V versus in-house V&V, and the role of contractors, if any, in the V&V need to be agreed upon and documented. It is also helpful for them to identify SMEs, to be used throughout the test and V&V, who are acceptable to both the test manager and the accreditation authority.

The accreditation team lead also needs to find out if the accreditation authority wants an accreditation team from within the accrediting organization (SIT and EW Test) or a team composed of subject matter experts from outside the organization (ETE Test). Once this is accomplished, write an accreditation plan describing the composition of the accreditation team, the accreditation objectives, and the broad accreditation requirements and acceptability criteria.

It is at this point that the overall V&V plan, describing the tailored process that will be used by the V&V team and the roles of the members of the IPT, should be written. This plan will be nonspecific with regard to actual V&V activities as the actual simulations, nodes, requirements, and acceptability criteria for the ADS-enhanced test environment have yet to be determined. It will match major V&V events with major test events and describe the specific V&V events that will be conducted to meet the previously agreed upon broad acceptability criteria. It will also identify future V&V plans that will be specific in nature. This plan will be used to cost the V&V process.

It will also describe in some detail how the conceptual model will be validated as this validation will occur prior to firm requirements being developed. Finally, it must identify the types of data required to evaluate how well the ADS-enhanced test environment meets the test objectives. These must be done at this step so that the test designer can make provisions for the collection of these data in the test design. The test manager must approve this plan after review by the test designer, schedule personnel, resource personnel, and the accreditation authority or representative.

Early validation of the conceptual model may begin during this step as SMEs are employed to review the federation objectives, approach, and technologies. The efforts of these SMEs should be documented for future use. Any work that tries to determine how well the ADS-enhanced test environment will represent the real environment should be considered as conceptual model validation.

5.2 Step 2. Develop Conceptual Model

A representation of the real-world domain of interest is developed and described in terms of a set of required objects and interactions. Most of the activities under this step are addressed by the test planning methodology. (JADS Special Report—A Test Planning Methodology-From Concept Development Through Test Execution)

This step is composed of three activities that are very important to the VV&A of an ADS-enhanced test environment.

5.2.1 Activity 2.1 – Develop Scenario

The basis for the V&V of the scenario(s) to be used in the test must be established here. The V&V team must work closely with the scenario developers, documenting data sources, doctrinal sources, and fidelity requirements. The requirements for the V&V of the scenario including the accrediting authority for the scenario should have been identified in the V&V plan developed during the previous step.

5.2.2 Activity 2.2 – Perform Conceptual Analysis

At this point that the distinction among test team members and V&V team members becomes fuzzy. The purpose of this activity, for the test team members, is to ensure that the conceptual model maps to the objectives, scenario, doctrine and tactics, and fidelity requirements of the test. In other words, determine how well the federation represents the real-world test environment and is the representation adequate. Do this in order to reduce risk prior to proceeding with the development of the federation. The V&V team wants to do the same thing. The two teams, if they are composed of different people, should work together within the IPT structure to ensure that this activity provides the required degree of risk reduction to the test manager, as this is its primary purpose.

With respect to the accreditation of the ADS-enhanced test environment, the validation of the conceptual model is a freebie. The results will be overshadowed by the validation of the constructed federation, and the accreditation decision will be based upon the performance of the federation, not a conceptual model. As stated above, conceptual validation is conducted in order to reduce risk.

5.2.3 Activity 2.3 – Develop Distributed Test Requirements

This is probably the most important activity, with respect to V&V, in the test planning methodology. Requirements to the person conducting V&V are like specifications to a person building a system. They dictate what the federation and its federates have to do to satisfy the test's objectives and measures. As stated in the test planning methodology, they fall into several broad categories. These categories are fidelity requirements, interaction requirements, latency requirements, data reliability requirements, and data analysis requirements. All require V&V effort to determine how well the federation and its federates meet the requirements.

It is critical that the V&V team be a part of the IPT and participate in the development of the requirements. The team can offer valuable insights as to what is measurable quantitatively and what must be measured qualitatively. It is equally important to include the accreditation team lead who has the responsibility of working with the test director and the accreditation authority to develop the acceptability criteria.

If the requirements state what the federation and its federates should do, the acceptability criteria state the minimum acceptable performance of the federation and its federates. Ideally, the tester would like for any simulation of a system, or process, to be perfect. Practically, close is often good enough. The acceptability criteria define close. If the federation and its federates fail to meet acceptability criteria, the accreditation team has the option of recommending that the federation be modified to meet the criteria or that the test proceed at the observed level of performance.

Once the requirements and acceptability criteria are identified, the detailed V&V plan(s) may be developed stating the specific V&V activities to be performed during the design, development, integration and testing of the federation. The test manager must approve these plans after review by the test designer, schedule personnel, resource personnel, and the accreditation team.

5.3 Step 3. Design Distributed Test

Distributed test participants (federates) are determined, and required functionalities are allocated to the participants. (JADS Special Report—A Test Planning Methodology-From Concept Development Through Test Execution)

The V&V team will need to work closely with the designer during this phase as it functions as a quality control team for the test manager. Its responsibility is to verify that HLA federation and federate rules have been followed, where applicable, and that the federation and federates conform to the object model template. It should also document any deviations from the HLA rules and the reason why the deviations were required.

The V&V team will also verify that the detailed design will meet the acceptability criteria arrived at during the last step and that the objectives of the test will be met by the proposed design. The design team will also conduct all or most of these tasks. The V&V team provides a second set of

eyes, with a slightly different perspective, to ensure that the design is adequate and to reduce risk within the test. The use of modeling tools, to model the federation and its federates, is recommended as a V&V or design tool during this step.

Finally, the V&V team will verify that adequate provisions are made in the design for the collection of data to V&V the final federation as assembled.

5.4 Step 4. Develop Distributed Test

The federation object model (FOM) is developed (if HLA is implemented), participant agreements on consistent databases/algorithms are established, and modifications to federates are implemented (as required). (JADS Special Report—A Test Planning Methodology-From Concept Development Through Test Execution)

This step is a continuation of the previous step and the V&V effort will be directed toward reducing risk. As federates are modified, they will be tested to ensure they meet requirements and that they continue to be HLA compliant.

The major emphasis at this point should be on ensuring that the federation will satisfy the test's requirements and objectives and less on standards compliance. The purpose of V&V is not to act as a standards policeman. Given the choice of a successful test meeting all requirements and objectives, or blind adherence to a standard, most test managers will decide on the former. Deviations from standards should be documented and reported to the standards authority along with the "fixes" employed to make the test environment work.

As they are identified, components of the federation, to include hardware items, may be procured and tested for HLA compliance and functionality. Items such as routers, crypto devices, and leased communication lines may also be tested and characterized within the federation configuration. It is recommended that a test bed federation with dummy federates be established using all of the actual hardware components before moving to the next step. The dummy federates receive and publish data in the same manner, and at the same rate, as the actual federates are expected to perform. This allows the test bed to experience the same interactions and data flow as the actual federation. Interactions and data flow may be determined from the model of the federation recommended in the previous step.

Using the test bed, hardware upper limits can be established for data flow within the federation, and the effects of changes to the architecture and data flow can be easily observed. Proper documentation is essential at this point, especially if changes are made to the architecture that deviates from the HLA standard.

5.5 Step 5. Integrate and Test Architecture

All necessary distributed test implementation activities are performed, and testing is conducted to ensure interoperability requirements are being met. (JADS Special Report—A Test Planning Methodology-From Concept Development Through Test Execution)

Up to this point, the purpose of the V&V conducted was to reduce risk. The V&V conducted during this step will be used to convince the accreditation team and the accrediting authority that the ADS-enhanced test environment, or federation if HLA is used, meets the acceptance criteria or at least performs well enough to proceed with the test.

V&V activities must be coordinated with the integration and functionality activities conducted by the test team. Ideally, no additional resource requirements will be placed on this step because of V&V. The purpose of this step is to assemble the ADS-enhanced test environment and determine how well it functions. Functionality is measured in terms of how well the environment meets its requirements. V&V also need to determine and document how well the environment functions. Whether it is called functionality testing or V&V is immaterial, both have the same objective.

Compliance issues should have already been answered and documented. That is why the use of the previously mentioned test bed is recommended. Deviations from HLA standards, in order to make the ADS-enhanced test environment meet requirements, will be more readily accepted than a HLA-compliant test environment that does not meet requirements.

Occasionally, a system or system of systems is so complex that the ADS-enhanced test environment only exists during actual test events. An example was the JADS ETE Test that contained an aircraft flying at 35000 feet over Texas. Because these events are often costly in terms of time and resources, the test manager is reluctant to allocate one of these events to V&V. Integration and functionality testing sufficient to satisfy the test manager that the ADS-enhanced test environment has a high chance of success during an actual test trial can take place on the ground. V&V of the almost real ADS-enhanced test environment can also be conducted to answer how well the environment meets the test's requirements. However, if the test environment exists only during the test, the V&V conducted are again risk reduction events.

5.5.1 Step 5a. Accredit ADS-Enhanced Test Environment

This is probably the easiest step in the process provided the previous VV&A activities have been performed as suggested. You normally do not arrive at this point in the process unless the ADS-enhanced test environment is performing well enough to satisfy the acceptability criteria established by the accreditation authority. In addition, if you have fully involved the members of the accreditation team in planning and conducting the V&V events, they already know how well the ADS-enhanced test environment meets the acceptability criteria. This is especially true if you provide them with the supporting documentation as it is produced, rather than dumping all of it on them just prior to the accreditation meeting.

Obviously, if the actual test environment has not been verified and validated, as described in the last step, the accreditation of the actual test environment cannot take place until after the test event(s) has been conducted. The accreditation will be based on the actual test performance of the environment and will confirm that the data collected during the test are valid. The accreditation team should meet prior to the test and consider the V&V conducted during the

integration and testing of the "near" actual test environment. It can still recommend proceeding to test with the stipulation that the final accreditation will not occur until after the test.

If this is not acceptable the accreditation authority will have to be willing to accept the allocation of the first test event to V&V with the understanding that if the test environment is subsequently accredited, the data collected during the V&V are valid SUT data.

5.6 Step 6. Execute Distributed Test and Analyze Results

The distributed test is executed, outputs are generated, and results provided. (JADS Special Report—A Test Planning Methodology-From Concept Development Through Test Execution)

Why V&V after the ADS-enhanced test environment has already been accredited? Well, simply put, most ADS-enhanced test environments are so complicated that the only way you can tell they are functioning correctly is to repeat some of the V&V activities during the test event. In order to prove that you have collected valid test data, you must establish that the ADS-enhanced test environment was meeting its requirements.

6.0 Summary

This report has established a basis for the VV&A of an ADS-enhanced test environment.

It has done so by reviewing the directives, regulations, and formal processes that apply to the VV&A of an ADS-enhanced test environment. They all have some differences in detail, but they all possess the common thread that if an ADS-enhanced test environment is used during the testing of a military system, it must first undergo VV&A.

Examples of the VV&A processes used by the three ADS-enhanced tests conducted by JADS were presented to demonstrate how VV&A may be tailored to fit the particular needs of a test. The three tests were from widely different test domains, used different ADS technologies, and yet were successfully verified, validated and accredited.

VV&A lessons learned during the conduct of the three tests were presented. The two most important lessons learned were that V&V are affordable if performed in conjunction with test design, integration, and functionality testing and that V&V reduce risk for the tester. If done wisely, V&V can provide a benefit to the tester, as opposed to being an onerous task required by regulation.

The last section of this report, the guide to conducting V&V of an ADS-enhanced test environment, is purposefully written in general terms to emphasize that each test must tailor the specifics of the VV&A process to its needs and requirements. What is critical is that VV&A must start at the beginning of the test process and the people involved must be an integral part of the test IPT. Once the test process begins areas of the test that exhibit the highest risk should be identified. The majority of the VV&A effort should be concentrated in those areas.

V&V can reduce risk!

Annex A: References

Air Force Instruction 16-1001, *Verification, Validation and Accreditation (VV&A)*

Army Regulation 5-11, *Management of Army Models and Simulations*

Department of Defense Directive 5000.59, *DoD Modeling and Simulation (M&S) Management*

Department of Defense Instruction 5000.61, *DoD Modeling and Simulation Verification, Validation and Accreditation*

Department of Defense Manual 5000.59, *DoD Modeling and Simulation (M&S) Glossary*

Department of Defense Regulation 5000.2, *Mandatory Procedures for Major Defense Acquisition Programs (MDAPS) and Major Automated Information System (MAIS) Acquisition Programs*

Department of Defense (DoD) Verification, Validation, and Accreditation (VV&A) Recommended Practices Guide

Department of the Army Pamphlet 5-11, *Verification, Validation, and Accreditation of Army Models and Simulations*

High Level Architecture (HLA) Federation Development and Execution Process (FEDEP): VV&A Overlay

JADS Special Report—A Test Planning Methodology-From Concept Development Through Test Execution

Recommended Practice for Distributed Interactive Simulation--Verification, Validation, and Accreditation

Secretary of the Navy Instruction 5000.2B, *Implementation of Mandatory Procedures for Major and Non-Major Defense Acquisition Programs and Major and Non-Major Information Technology Acquisition Programs.*

Secretary of the Navy Instruction 5200.40, *Verification, Validation, and Accreditation (VV&A) of Models and Simulations*

www.DMSO.mil

www.JADS.abq.mil

Annex B: Acronym List

ADS	advanced distributed simulation
AFEWES	Air Force Electronic Warfare Evaluation Simulator, Fort Worth, Texas; Air Force managed with Lockheed Martin Corporation
AFI	Air Force instruction
AR	Army regulation
ATEWES	Advanced Tactical Electronic Warfare Environment Simulator
C4ISR	command, control, communications, computers, intelligence, surveillance and reconnaissance
DAB	Defense Acquisition Board
DAPAM	Department of the Army pamphlet
DIS	distributed interactive simulation
DMSO	Defense Modeling and Simulation Organization, Alexandria, Virginia
DoD	Department of Defense
DON	Department of the Navy
DPRB	Defense Planning and Resources Board
DSM	digital system model
DT&E	developmental test and evaluation
ETE	JADS End-to-End Test
EW	JADS Electronic Warfare Test
EWIR	electronic warfare integrated reprogramming database
FAT	federate acceptance test
FEDEP	federation development and execution process
FIT	federate integration test
FOM	federation object model
GTRI	Georgia Tech Research Institute, Atlanta, Georgia
HITL	hardware-in-the-loop (electronic warfare references)
HLA	high level architecture
HWIL	hardware-in-the-loop (system integration references)
IEEE	Institute of Electrical and Electronics Engineers
IPT	integrated product team
ISTF	installed systems test facility
JADS	Joint Advanced Distributed Simulation, Albuquerque, New Mexico
Joint STARS	Joint Surveillance Target Attack Radar System
JROC	Joint Requirements Oversight Council
JT&E	joint test and evaluation
JTF	joint test force
M&S	modeling and simulation
MAIS	Major Automated Information System
MDAPS	major defense acquisition programs
MSEA	modeling and simulation executive agent
OAR	open air range
OSD	Office of the Secretary of Defense

OT&E	operational test and evaluation
POM	program objectives memorandum
PPBS	Planning, Programming, and Budgeting System
RF	radio frequency
RPG	recommended practices guide
SE	synthetic environment
SECNAV	Secretary of the Navy
SECNAVINST	Secretary of the Navy instruction
SIT	JADS System Integration Test
SME	subject matter experts
SUT	system under test
T&E	test and evaluation
TCAC	Test Control and Analysis Center at JADS, Albuquerque, New Mexico
USD (A&T)	Under Secretary of Defense for Acquisition and Technology
V&V	verification and validation
VV&A	verification, validation and accreditation
VV&C	verification, validation and certification